GCE

Geology

H414/02: Scientific literacy in geology

Advanced GCE

Mark Scheme for Autumn 2021

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This mark scheme is published as an aid to teachers and students, to indicate the requirements of the examination. It shows the basis on which marks were awarded by examiners. It does not indicate the details of the discussions which took place at an examiners' meeting before marking commenced.

All examiners are instructed that alternative correct answers and unexpected approaches in candidates' scripts must be given marks that fairly reflect the relevant knowledge and skills demonstrated.

Mark schemes should be read in conjunction with the published question papers and the report on the examination.

Annotations

Annotation	Meaning
	Correct response
	Incorrect response
	Omission mark
BOD	Benefit of doubt given
CON	Contradiction
RE	Rounding error
SF	Error in number of significant figures
ECF	Error carried forward
L1	Level 1
L2	Level 2
L3	Level 3
NBOD	Benefit of doubt not given
SEEN	Noted but no credit given
I	Ignore
BP	Blank page

Abbreviations, annotations and conventions used in the detailed Mark Scheme (to include abbreviations and subject-specific conventions).

Annotation	Meaning
DO NOT ALLOW	Answers which are not worthy of credit
IGNORE	Statements which are irrelevant
ALLOW	Answers that can be accepted
( )	Words which are not essential to gain credit
__	Underlined words must be present in answer to score a mark
ECF	Error carried forward
AW	Alternative wording
ORA	Or reverse argument

Question			Answer	Marks	AO element	Guidance
1	(a)	(i)	removal of sediment **AND** its transport **OR** the wearing away of the land surface (during transport) **OR** the wearing away of sediment by abrasion / attrition (during transport) ✓	1	1.1a	
	(a)	(ii)	**ANY** two from: • grains become more texturally mature with transport as corners get removed / due to attrition / abrasion ✓ • grains get finer with transport as corners get removed **/** due to attrition / abrasion ✓ • grains get rounder with transport as corners get removed / due to attrition / abrasion ✓ • grains get better sorted with transport as corners get removed / due to attrition / abrasion ✓ • grains become more quartz rich / more compositionally mature as other minerals decompose / fracture / are eroded away during transport ✓	2	1.1a	
	(b)	(i)	**ANY** two from: • clay minerals may be formed from breakdown of feldspars ✓ • hematite may form as an oxidation product in deserts ✓ • minerals are in solution / dissolved in groundwater ✓ • dissolved minerals may be products of pressure solution elsewhere ✓ • groundwater / pore fluid passes through sediment / pore space ✓ • minerals are precipitated / crystallise in the pore space ✓ • cement binds the grains together ✓	2	1.1c	**ALLOW** correct named clay mineral
	(b)	(ii)	any correct named cement, e.g., quartz / calcite ✓	1	1.1a	**ALLOW** limonite / siderite / glauconite

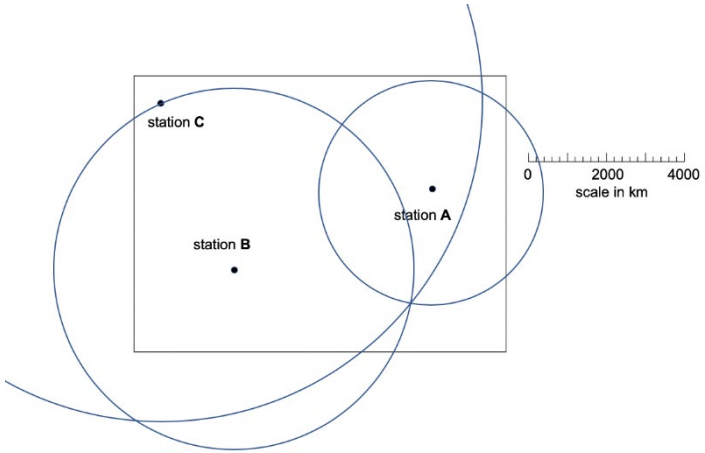
Question			Answer	Marks	AO element	Guidance
	(b)	(iii)	gas evolution from peat (whilst under pressure / compaction) **OR** CH_4 / CO_2 / SO_2 evolved **OR** loss of water occurs ✓ resulting in a (relative) increase in carbon content ✓	2	1.1a 2.1a	**DO NOT ALLOW** ideas that are not chemically based **ALLOW** loss of any correct named gas
	(c)	(i)	**ANY** two from: • compaction / load pressure / weight of overlying sediment / overburden causes dis(solution) ✓ • occurs at contacts points between grains ✓ • (large quantities of $CaCO_3$ are) taken into solution ✓ • clay is concentrated in layers as it is insoluble / does not go into solution / forms a residue ✓ • (re)crystallisation / precipitation from fluids occurs where stable ✓	2	3.1a	**ALLOW** compression
	(c)	(ii)	porosity **AND** permeability decrease ✓	1	3.1b	
	(c)	(iii)	clay originally disseminated in the limestone is now concentrated in layers **OR** clay is the insoluble residue **OR** the clay results from impurities in the limestone ✓	1	3.1b	
	(c)	(iv)	**ANY** one from: • easy to cut into thin layers due to composition ✓ • lacks porosity, so resistant to wear / does not crumble / is impermeable ✓ • recrystallised / hard(er), so stays polished / is hard wearing ✓ • mechanically strong, so durable ✓ • stylolites make the appearance of the rock more attractive ✓	1	2.1a	**ALLOW AW** **DO NOT ALLOW** non geological ideas
	(d)	(i)	**A** desiccation cracks ✓ **B** imbrication ✓ **C** cross-bedding ✓	3	3.1b	1 mark for each correct answer. **A – ALLOW** mud cracks **C – ALLOW** ripple marks
	(d)	(ii)	**A AND C** ✓	1	1.1d	

Question			Answer	Marks	AO element	Guidance
	(e)		**beach – ANY** one from: • composed of sand and gravel with rounded grains ✓ • medium - coarse grained / may include pebbles ✓ • orthoquartzites / quartz-rich sediment ✓ • may contain shell fragments / symmetrical ripple marks / burrows ✓ **shallow sea / wave influenced – ANY** one from: • form crossed-bedded sands / bioturbated sands / offshore sandbars ✓ • may contain glauconite ✓ • may contain asymmetrical ripples / burrows ✓ **below wave base – ANY** one from: • fine grained / muds and silts ✓ • many marine organisms / burrows ✓	3	2.1a	must have one marking point from each section. mark annotated diagram(s) as text

Question			Answer	Mark	AO element	Guidance
2	(a)	(i)	<table><tr><td>260</td><td>**080**</td></tr><tr><td>222</td><td>**042**</td></tr><tr><td>012</td><td>**012**</td></tr><tr><td>328</td><td>**148**</td></tr><tr><td>055</td><td>**055**</td></tr><tr><td>355</td><td>**175**</td></tr></table> ✓✓	2	2.1b	6 or 5 correct for 2 marks 3 or 4 correct for 1 mark Less than 3 correct 0 marks
	(a)	(ii)	experiment 1 = 069.5 / 070° **AND** experiment 2 = 085.3 / 085° ✓	1	2.1b	Must have both values **ALLOW ECF** from 2(a)(i)

Question			Answer	Mark	AO element	Guidance
	(a)	(iii)	**ANY** two from: • shells may be different sizes / shapes ✓ • differences in water pressure / speed / volume ✓ • tubing may have moved from centre ✓ • water left on tray / shells wet from first experiment ✓ • shells placed in slightly different places ✓ • iron in bench / lab interfering with compass readings ✓ • conducted in different parts of the lab so trends different ✓	2	3.1d	**ALLOW AW**
	(a)	(iv)	**ANY** one from: • control the flow rate / direction of the water ✓ • use more linear shells, such as *Solen* ✓ • create a drain hole for excess water ✓ • reduce the incline to less than 10° ✓ • conduct experiment away from sources of iron ✓ • dry the tray / shells between experiments ✓ • mark the position of the shells on the tray so they are placed in the same position each time ✓ • add sediment to the tray to make it more realistic ✓	1	3.1f	**ALLOW AW**
	(a)	(v)	**ANY** three from: • could be used to model if there was a current when a sedimentary rock formed ✓ • could be used to model the direction of current flow ✓ • shows shells tend to align in the direction of flow **OR** at right angles to flow ✓ • could compare to trends of fossils (on bedding planes) ✓ • the experiment only models a unidirectional current / river, (but mussels are marine organisms) ✓ • reality is more complex, e.g., there is sediment present **OR** interactions between currents **OR** in the ocean **OR** results in shell concentrations **OR** winnowing / sorting / rip currents / longshore drift / tides occur ✓	3	3.1c	

Question			Answer	Mark	AO element	Guidance
	(b)		**ANY** four from: • selection of suitable shell types ✓ • use the same number / mass of shells in each repeat ✓ • place shells in suitable container (with lid) • agitate / shake for set time period ✓ • masses / sediment (of known mass) could be placed (in container) with shells ✓ • describes way of separating different fragment sizes, e.g., using sieves **OR** measuring maximum diameter of fragments **OR** finding the mass of fragments over a particular size ✓ • measures mass of size fractions **OR** calculates percentage attrition ✓	**4**	**2.1b**	

Question			Answer	Mark	AO element	Guidance
3	(a)	(i)	**B** = 6 ✓ **C** = 9 ✓	2	1.1b 3.1b	
	(a)	(ii)	**B** = 4700 +/- 300 km ✓ **C** = 8000 +/- 300 km ✓	2	2.1b	**ALLOW ECF** from 3(a)(i)
	(a)	(iii)	 ✓ ✓ ✓	3	2.1b	1 mark for 1 correct arc 2 marks for 3 correct arcs 1 mark for locating the epicentre / can be in the centre of a triangle of error **ALLOW ECF** from 3(a)(ii)
	(b)	(i)	subduction zone **OR** subducted slab / plate **OR** subducted oceanic lithosphere ✓	1	3.1c	**ALLOW** convergent plate margin **DO NOT ALLOW** partial melting or low velocity zone alone
	(b)	(ii)	**ANY** two from: • P-waves travel faster through subducted slab **AND** P-waves travel slower where there is rising magma / partial melting ✓ • P-waves travel faster through the colder / denser material **OR** P-waves travel slower through hotter / less dense material ✓	2	1.1c	

Question			Answer	Mark	AO element	Guidance
			• the subducted slab is more rigid / more incompressible **OR** areas of rising magma / partial melting are less rigid / less incompressible ✓			
	(b)	**(iii)**	**ANY** one from: • a low velocity zone marks the asthenosphere as P / S waves slow down as they enter 5% partial melt ✓ • tomographic imaging shows the top of the asthenosphere at 75-100 km depth **OR** the base of the asthenosphere at approximately 250 km depth **OR** the asthenosphere is between 75-100 to 250 km depth ✓ • there is an increase in P / S wave speed at the base of the asthenosphere as the mantle becomes solid / as zone of 5% partial melt ends ✓	**1**	**2.1a**	
	(b)	**(iv)**	**ANY** one from: • oceanic crust is too thin for intermediate / deep focus earthquakes ✓ • shallow focus earthquakes are triggered by rising magma at the rift ✓ • shallow focus earthquakes occur due to lateral movement of transform faults ✓	**1**	**2.1a**	

Question			Answer	Mark	AO element	Guidance
4	(a)	(i)	**ANY** one from: mass extinction events **OR** asteroid impacts **OR** large-scale flood events **OR** large-scale volcanism ✓	1	1.1c	**ALLOW** bedding planes in **Fig. 4.1** are at different angles suggesting violent tectonic forces / upheaval / earthquakes **OR** angular clasts of Silurian rock in **Fig. 4.1** suggest a flash flood event
	(a)	(ii)	theory: Uniformitarianism **OR** Gradualism ✓ physical process: The Rock Cycle ✓	1 1	1.1a	
	(a)	(iii)	geological processes observable now / today acted the same way in the past ✓	1	1.1a	
	(a)	(iv)	**ANY** two from: • superposition ✓ • law of included fragments ✓ • cross-cutting relationships ✓ • original horizontality ✓	2	1.1a	**ALLOW** correct descriptions of these relative dating principles **ALLOW** unconformity for cross-cutting relationship
	(a)	(v)	**ANY** one from: • superposition: oldest rocks at base of sequence as deposited first **OR** rocks get successively younger upwards **OR** youngest rocks at top of sequence as deposited last ✓ • included fragments: fragments must be older than the rock in which they are contained **OR** older included fragments have been eroded and redeposited **OR** fragments in Devonian rocks have come from Silurian rocks ✓ • cross-cutting relationships: angular unconformity must be younger than the rocks it cuts across **OR** folded rocks were eroded then horizontal rocks deposited on top of them **OR** younger rocks cut across older rocks ✓	1	1.1a	**ALLOW** any valid explanation

Question			Answer	Mark	AO element	Guidance
			• original horizontality: beds were deposited horizontally **OR** if not horizontal, beds have been uplifted and tilted ✓			
	(a)	**(vi)**	beds containing the same fossils are the same age **OR** uses the first and last appearance of fossils / stratigraphic range ✓	**1**	**1.1a**	
	(a)	**(vii)**	fragments of older rock / fossils found in a younger rock ✓ allows the relative ages of units to be deduced as included fragments have come from older rock units **OR** (older fossils in the rock) make the rock appear to be older than it is ✓	**1** **1**	**2.1a**	
	(a)	**(viii)**	**ANY** one from: • he recognised faunal succession **OR** fossil faunas succeed one another in a definite age order ✓ • he suggested that rocks containing the same fossil assemblages are the same age **OR** rocks could be correlated on the basis of their fossil assemblages ✓ • William Smith found other unconformities ✓ • excavations of the canals allowed William Smith to collect large numbers of fossils from rock strata across the country ✓	**1**	**1.1c**	**ALLOW AW**
	(b)	**(i)**	**ANY** two from: • rates of sedimentation vary over time in the same location ✓ • rates of sedimentation vary geographically / laterally ✓ • rates of sedimentation vary between different rock types / depositional environments, e.g., mudstone & sandstone / deep marine & terrestrial ✓ • there may have been periods of erosion removing sediments leading to errors in rate calculation ✓ • there are no surviving sedimentary rocks from the early Earth **OR** ancient sedimentary rocks have been recycled by plate tectonic processes ✓	**2**	**1.1c**	

<table>
<tr><th colspan="3">Question</th><th>Answer</th><th>Mark</th><th>AO element</th><th>Guidance</th></tr>
<tr><td></td><td>(b)</td><td>(ii)</td><td>FIRST CHECK ANSWER ON ANSWER LINE
if answer = 0.0196 (mm per year) award 2 marks

working showing thickness of sediment ÷ time period over which the sediments were deposited

= <u>0.0196</u> (mm per year) ✓✓</td><td>2</td><td>2.1b</td><td>

1 mark for correct working

1 mark for correct answer to 3 significant figures</td></tr>
<tr><td></td><td>(c)</td><td>(i)</td><td><table><tr><th>Structural Events</th><th>Number</th></tr><tr><td>Youngest</td><td>6</td></tr><tr><td></td><td>2</td></tr><tr><td></td><td>4</td></tr><tr><td>Oldest</td><td>8</td></tr></table>✓</td><td>1</td><td>3.1b</td><td>ALL correct for 1 mark</td></tr>
<tr><td></td><td>(c)</td><td>(ii)</td><td><table><tr><th>Sedimentary Events</th><th>Number</th></tr><tr><td>Youngest</td><td>3</td></tr><tr><td></td><td>7</td></tr><tr><td></td><td>1</td></tr><tr><td>Oldest</td><td>5</td></tr></table>✓</td><td>1</td><td>3.1b</td><td>ALL correct for 1 mark</td></tr>
</table>

Question			Answer	Mark	AO element	Guidance
5	(a)	(i)	**FIRST CHECK ANSWER ON ANSWER LINE** **If answer = 55.68 (kN m^{-2}) award 3 marks** σ = (18 x 1) + (19 x 0.7) + (2 x 22) = 75.3 ✓ μ = 9.81 x 2 = 19.62 ✓ σ^1 = 75.3 – 19.62 = <u>55.68</u> kN m^{-2} ✓	**3**	**2.1b**	
	(a)	**(ii)**	**ANY** one from: (rock) drains to remove water (and reduce pore fluid pressure) ✓ grouting / shotcrete to reduce permeability ✓ vegetation as plants reduce infiltration of water / 'fix' soil in place ✓	**1**	**1.1d**	
	(b)	**(i)***	Refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question. **Level 3 (5–6 marks)** Uses a good balance of the general **AND** geological information / evidence from the text **AND** knowledge of the properties of smectite and illite clays **AND** makes judgements on the causation of the landslide. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.* **Level 2 (3–4 marks)** **EITHER** Uses some of the general **AND** geological information / evidence **AND** makes judgements on the causation of the landslide. **OR**	**6**	**3.1c** **2.1a** **3.1d**	**Indicative points may include:** **AO3.1c Evaluates information and evidence** **general information** • excessive rainfall may be final trigger • low-cost housing with shallow foundations • quarrying / deforestation • housing built on 25° slope • area susceptible to flash floods • drainage trenches retained water • cracks and fissures in walls & pavements **geological information** • bedrock heavily fractured & interbedded so weak • clay is weak / incompetent • beds dip from mountains above area making them unstable • area had high concentration of smectite and suffered slope failure • surrounding area had low concentration of smectite and did not fail

Question			Answer	Mark	AO element	Guidance
			Uses detailed geological information / evidence from the text **AND** makes judgements on the causation of the landslide. *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** Some relevant information / evidence is lifted from the question **AND** there is an attempt at a judgement on the causation of the landslide. Answer may be unbalanced. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*			**AO2.1a Applies knowledge and understanding of the changing properties of clay** • soil containing as little as 5% clay minerals can be subject to shrink-swell • illite is a non-expanding / low shrink-swell (2:1) clay • smectite is an expanding / high shrink-swell (2:1) clay • smectite can expand up to 1500% of original volume when saturated • clay slopes are generally only stable below 10° angle • evidence of shrink-swell are cracks and fissures in walls and pavements **AO 3.1d Makes judgements on causation based on evidence provided** • fractured bed rock allows percolation of water • water adds weight making a failure more likely • fractured bed rock is weak • deforestation reduces hillside cohesion and allows rise of water table • over-quarrying increases run-off • hydrostatic pressure breaks grain-to-grain cohesion • hydrostatic pressure forces apart bedding planes / lubricates bedding planes • bedding planes likely to fail down dip • 25° slopes too steep for clay
	(b)	**(ii)**	lime **OR** calcium oxide treatment ✓ changes Na-smectite to Ca-smectite **OR** Ca-smectite expansion is only 100% **OR** Na-smectite expansion is 1500% ✓	**1** **1**	**2.1b**	**ALLOW** use of cement **ALLOW** alters the composition / structure of clay(s) to prevent shrinking and swelling

Question			Answer	Mark	AO element	Guidance
	(b)	(iii)	**ANY** two from: • study of aerial / satellite photographs **OR** desk study ✓ • surface mapping (folds / faults / joints / dip of beds) **OR** mapping fracture density **OR** slope mapping ✓ • sub-surface mapping, e.g., test pits / boreholes / drilled cores ✓ • geophysical survey, e.g., seismic refraction / resistivity ✓ • soil mechanics measurements **OR** laboratory testing of rock / soil samples **OR** measurements of rock strength (compressive / shear) ✓ • integration of data into GIS ✓	**2**	**3.1c**	**ALLOW** one mark for list of two correct techniques **ALLOW** any correct named appropriate geophysical surveying technique, e.g., ground penetrating radar

Question			Answer	Mark	AO element	Guidance
6	(a)	(i)	lower flow rate / less aquifer recharge / less water in the aquifer **AND** increases bromate concentration in groundwater **OR** there is less dilution of the bromate in groundwater ✓	1	2.1a	**ORA**
	(a)	(ii)	**FIRST CHECK ANSWER ON ANSWER LINE** **If answer = 25.2 (µg/l) award 2 marks** 1200 m^3 x 1000 = 1200000 litres **AND** 1820 m^3 x 1000 = 1820000 litres ✓ ((1200000 + 1820000) x 10) ÷ 1200000 = 25.2 (µg/l) **OR** ((1200 + 1820)) x 10) ÷ 1200 = <u>25.2</u> (µg/l) ✓	2	3.1a	**ALLOW** 25.17 **OR** 25
	(a)	(iii)	**ANY** two from: • remove contaminated substrate ✓ • pump (and treat) bromate contaminated water from a borehole closer to the contamination source ✓ • phytoremediation – use of plants to remove bromate ✓ • use ion exchange process to remove bromate ✓	2	2.1a	
	(b)		(dis)solution of chalk / $CaCO_3$ / calcite / carbonate by groundwater creating a void space / caves ✓	1	2.1a	**ALLOW** compaction of aquifer due to over extraction / abstraction of water from wells

Question			Answer	Mark	AO element	Guidance
7	(a)	(i)	an animal with four limbs **OR** an animal that largely walked on four limbs ✓	1	1.1a	
	(a)	(ii)	**ANY** two from: • amniotic egg increased survival of young / protection of embryo ✓ • eggs could be laid away from a water source / increase in niches ✓ • less bones / more muscle and tendons ✓ • increased flexibility / manoeuvrability of animal ✓	2	1.1c	
	(a)	(iii)	**ANY** one from: amniote eggs have a hard shell (e.g., like chicken eggs) (so can lay eggs on land) **AND** anamniote eggs have no shells (e.g., like frog spawn) (so eggs need to be laid in water) ✓	1	1.1a	**MUST** give a morphological difference **ALLOW** amniote eggs have a membrane **AND** anamniote eggs do not
	(a)	(iv)	Refer to the marking instructions on page 5 of this mark scheme for guidance on how to mark this question. **Level 3 (5–6 marks)** Uses a good balance of the information / evidence from the text **AND** knowledge of the modes of life of different groups of named Archosaurs **AND** Makes links between bone structure and potential modes of life of some of the different Ornithosuchia with reasons. *There is a well-developed line of reasoning which is clear and logically structured. The information presented is relevant and substantiated.*	6	2.1a 3.1c	**Indicative points may include:** **AO3.1c Evaluates information and evidence** • compares position of bones in the two types of Archosaurs • links bone structure to mode of life / locomotion with examples • Pseudosuchia / crocodilian ankle structure mostly used whilst swimming, with limited movement on land • Ornithosuchia ankle structure linked to life on land • Ornithosuchia have diverse members which walk, run, hunt, graze or fly **AO2.1a Applies knowledge and understanding** • Ornithosuchia ankles adapted to the need for additional weight bearing on land • Pseudosuchia / crocodilian skeletons supported by water so less need for weight-bearing

Question			Answer	Mark	AO element	Guidance
			Level 2 (3–4 marks) **Either** Uses some of the information / evidence from the text **AND** links this the modes of life of different groups of named Archosaurs. **OR** Uses more detailed ideas and evidence about Ornithosuchia to link morphology to specific examples of their modes of life. Answer may be unbalanced. *There is a line of reasoning presented with some structure. The information presented is relevant and supported by some evidence.* **Level 1 (1–2 marks)** Some relevant information / evidence is lifted from the question about some of the different groups of Archosaurs **AND** there may be an attempt to link to their modes of life **OR** Discusses Ornithosuchia / dinosaur mode of life, largely ignoring the content in the article. Answer may be unbalanced. *There is an attempt at a logical structure with a line of reasoning. The information is in the most part relevant.* **0 marks** *No response or no response worthy of credit.*			• describes how Ornithosuchia ankle structure supports grazing, running and hunting – both herbivorous and carnivorous modes of life • describes purpose of reversed big toe in birds / *Archaeopteryx* allowing perching • discusses changes in bone density / hollow bones in birds to allow flying • Compares morphology / modes of life of Ornithischian and Saurischian dinosaurs within the Ornithosuchia

Question			Answer	Mark	AO element	Guidance
	(b)	(v)	short and flattened peg shaped teeth = **SS** ✓ large olfactory lobes = **ST** ✓ hinged jaw containing teeth suitable for grinding = **O** ✓ primitive hips with pubis bone which points forward = **SS AND ST** ✓	4	2.1a	
	(c)		**ANY** four from: • definition of convergent evolution – independent evolution of same / similar features in unrelated / distantly related species ✓ • birds and pterosaurs do show convergent evolution as they have similar (morphological) features ✓ • both birds and pterosaurs evolved wings (for flight) ✓ • both evolved a stabilising tail ✓ • but structures for flight are different in pterosaurs and birds ✓ • but pterosaurs had teeth / had skin-like membranes held up by wing fingers ✓ • but birds have complex flight feathers ✓	4	3.1c	

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